REMARKS

Specification.

1. Applicant submits that typographical errors only were corrected and that no new matter is added.

Claims.

2. Claim 4 is amended to correct typographical errors. A new Claim 9, dependent on Claim 4, is added. Support can be found in the Specification in section, Summary, and in Claim 1 as originally filed.

Applicant draws attention to Claim 1 as originally filed. There were typographical errors and, as the Examiner put it in the first Office Action, "Further, Claim 1 is in narrative form... ."

To rectify the informal errors with Claim 1, Claim 1 was canceled and a new Claim 4 (a corrected Claim 1) was added in the subsequent response.

Such Claim 4 was subsequently allowed.

It has been since discovered that allowed Claim 4 is also with inadvertent informal errors: transcription (*e.g.* the Greek letter, phi, became sigma) and the bottom portion of original Claim 1 was omitted.

Applicant submits herewith an amended Claim 4, which corrects transcription errors only, and a new dependent Claim 9 (dependent on allowed Claim 4), which contains only the matter that was in the original Claim 1 as filed.

3. Claims 2, 5, and 7 are amended to delete the word, 'different.' Support can be found in the (amended) Specification on page 14, lines 16-17, as follows (emphasis added):

> 4. Apply a ***possibly different*** method from C_1 to estimate a covariance matrix $\Phi(t)$ from the history of $\phi(t)$s.

CONCLUSION

Should the Examiner deem further discussion of the subject patent application helpful, the Examiner is invited to telephone Applicant's attorney, Michael A. Glenn, at (650) 474-8400.

Respectfully Submitted,

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Amendment to the Specification

Please amend the Specification as follows:

(On page 1, line 29 through page 2, line 3)

Within the world of risk modeling there has, until recently, been a need to compromise on objectives. As long as one's focus was confined to securities within a single market, U.S. equities say, detailed analyses have been possible. When one's perspective broadens to consider equities from around the world, currencies ~~and, however~~, etc., the depth of analysis ~~has necessarily~~ contracts~~ed~~. Fundamentally this compromise between depth and breadth has been necessitated by the limitations of computing technology. In the last few years, however, these limitations have been much reduced.

(On page 2, line 26 through page 3, line 6)

In the last 25 years, there has been rapid growth in types of assets, such as options, where the variance may not be an adequate description of risk. In these cases, there is a set of underlying variables, such as underlying asset prices, whose riskiness is captured by their variances. Then Ω is the covariance matrix of the underlying variables, such as underlying asset prices. For expositional simplicity, and because the variance does provide a first measure of risk, we will use portfolio covariance as a risk measure and use Ω to ~~devote~~ denote the asset level covariance matrix.

(On page 3, line 22 through page 4, line 6)

The statistical properties of the estimator $\hat{\Omega}$ depend crucially on two parameters: the number of periods t in the estimate and the number of assets, ~~a~~ N, covered by the estimate. If $N>t$ then we may find portfolios h such that

$$h^t \hat{\Omega}\, h = 0$$

over the sample period. Such portfolios appear to be risk free, but in fact are not. Technically this condition is expressed by saying that $\hat{\Omega}$ fails to be positive definite. If a covariance matrix which is not positive definite is used for portfolio construction there will be a strong tendency to buy into the apparently risk free portfolios. The

result is a severely biased risk estimate, with realized risks proving significantly higher than forecast risks. For this reason a positive definite covariance matrix is a basic requirement, and thus one requires $t > N$. Econometric considerations limit t to approximately 60, while practical applications may require N on the order of 1000. Thus, the historical asset-by-asset covariance matrix is of only limited practical utility.

(On page 4, line 10 through page 5, line 8)

The limitations of the historical covariance matrix motivate the search for a more robust estimator of the asset covariances. The standard solution is to invoke a factor model. A factor model is a linear model for asset returns such that

$$\cancel{r_i(t) = \sum_{j=i}^{m} X_{ij}(t) f_j(t) + \varepsilon_i(t)}$$

$$\underline{r_i(t) = \sum_{j=1}^{m} X_{ij}(t) f_j(t) + \varepsilon_i(t)}$$

where $X_{ij}(t)$ is termed the exposure of asset i to factor j, $f_j(t)$ is termed the return to factor j and $\cancel{\varepsilon_j(t)}$ $\underline{\varepsilon_i(t)}$ is termed the specific return to asset i. The returns need not be linear in the factors, as in the case of options. Our interest is in developing a covariance matrix for factors across many asset classes and the linearity assumption does not impact the interest in any manner: Non-linear instruments may bye valued directly given factor realization. For portfolio risk analysis, the linear approach is a widely-used first order approximation which greatly speeds up computations. It is further assumed that the factors f_j capture all common sources of return between assets, or equivalently that

$$\underline{(1)}\ \operatorname{cov}(f_j(t), \varepsilon_i(t)) = 0$$

for all factors $f_j(t)$ and specific returns $\cancel{\varepsilon_j(t)}$ $\underline{\varepsilon_i(t)}$ and that

$$\underline{(2)}\ \operatorname{cov}(\varepsilon_i(t), \varepsilon_k(t)) = 0$$

for distinct assets i and k. In this case with a bit of algebraic manipulation one can show

$$\Omega = XFX^t + \Delta$$

where

$$F_{ij}(t) = \mathrm{cov}(f_i(t), f_j(t))$$

and

$$\Delta_{ij}(t) = \mathrm{cov}\,(\varepsilon_i(t),\ \varepsilon_j(t))$$

$$= \begin{cases} \mathrm{var}(\varepsilon_i) & \text{if } i = j \\ 0 & \text{otherwise} \end{cases}$$

F is the common factor covariance matrix, and Δ is the (diagonal) matrix of specific risk. We estimate the quantities F and Δ historically.

(On page 7, line 25 through page 8, line 8)

However one generates a factor structure, one is faced with the problem of assessing its adequacy. For exploratory techniques one is guaranteed to find a structure ~~which~~ that meets the basic assumptions (1) and (2) of the factor model over the time period in which the model is estimated. The essential assessment then is whether the factor exposures estimated in this way remain stable in subsequent time periods. For returns based confirmatory factor analysis, stability of the factor exposures is again the basic criteria of success. For confirmatory analysis, by contrast, the technique ~~only~~ guarantees only that property (1) will hold. Thus, a test of the model is verifying how well property (2) holds -- *i.e.* are the specific returns of distinct assets uncorrelated within measurement error? It is an advantage of the confirmatory methodology that this check of the model's adequacy may be made on the estimation data itself. By contrast, the exploratory method requires data subsequent to the estimation data to arrive before the internal consistency of the model can be assessed.

(On page 8, lines 22 through 33)

Confirmatory factor analysis for equities in a single country reveals that equity returns are driven by industry and style related factors. Industry related factors are self-explanatory: each firm functions within a single industry or across multiple industries, and the exposure of a firm to different industries may be computed by using a combination of sales, assets, and income from the different industries. Style related factors are based on firm fundamentals, such as size, growth, or relative trading activity, and exposure to style based factors are computed using fundamental accounting information, e.g *assets*, or market~~ing~~ information, e.g. *capitalization, trading volume*. The prevalence of different industries, the availability of fundamental and market data, and the local behavior of the market then determine the final factor structure that is used for equities in a single country.

(On page 9, lines 10 through 24)

When integrating across many assets classes, it has in the past been difficult to work with the factors from the single asset class models, particularly for equities. The problem, discussed in detail below, is simply that there are too many factors, differing factor histories, and different types of statistical analyses that may be applied to each asset class. The natural simplification, which eliminates the need for aggregating different types of model, is to impose a common factor model structure across all asset classes. For example, one could impose a single factor model so that the aggregation process requires only the estimation of the correlation between the various factors, while at the individual asset level one ~~only~~ has <u>only</u> to estimate asset exposures and residual risk. As described below in detail, this has been past practice when modeling global equities. This greatly simplifies the aggregation task but either leaves the portfolio manager with an inferior model or yields inconsistent results between the various levels within the firm hierarchy, neither of which result is ~~actually~~ necessary, nor desirable.

(On page 12, line 25 through page 13, line 2)

Synthesizing all of this ~~information~~ <u>information,</u> we are led to a new vision of global equities. Whereas the Global Equity Model saw global equities as a homogeneous group caught in a simple factor structure, we now see each local market as the homogeneous grouping with different markets linked together into a global matrix by various regional and global effects. The natural realization of this vision is to fit a

factor model to each local market. The local models can be customized to each market to capture its special features and to best exploit the available data. The local analysis must then somehow be integrated into a global analysis. The work of Hui has been pointing in this direction since 1995. How to achieve the integration of local models has, however, been an elusive point. It would be advantageous to resolve this difficulty.

(On page 14, lines 13 through 17)

3. Apply a method from C_1 to estimate a covariance matrix $G(t)$ from the history of $g(t)$s.

4. Apply a possibly different method from C_1 to estimate a covariance matrix $\Phi(t)$ from the history of $\phi(t)$s.

(On page 15, lines 1 through 3)

2. Let ~~be~~ $F_2(t)$ be the block diagonal matrix whose diagonal blocks contain the asset class factor covariance matrices~~,~~ $F(y_i,t)$ in the same order as they appear in $F_1(t)$; the off-block diagonal elements are zero.

(On page 26, lines 23 through 24)

Substituting the first model into the second and rearranging terms we get

$$\cancel{f_j^i(t) = \sum_{k-1}^{46} Y_{jk}^i(t) g_k(t) + \phi_j^i(t)}$$

$$\underline{f_j^i(t) = \sum_{k=1}^{46} Y_{jk}^i(t) g_k(t) + \phi_j^i(t)}$$

Amendment to the Claims

Please amend Claim 4 and add new Claim 9 as follows:

1. (canceled)

2. (currently amended) A computer implemented method for combining two or more risk models for providing an investor with a risk model with wider scope than its constituent parts, comprising the steps of said computer:

denoting a class of algorithms for constructing estimates of covariance matrices from time histories of data;

denoting a class of asset classes;

denoting a class of multi-factor risk models for said denoted class of asset classes; and

constructing risk models for each asset class as follows:

applying a method from said denoted class of algorithms to estimate a first covariance matrix from a history;

applying a ~~different~~ method from said denoted class of algorithms to estimate a second covariance matrix from a history; and

combining asset class risk models based on said class of multi-factor risk models and using said estimated first and second covariance matrices to form and output a risk model with broad coverage that is consistent with each asset class model.

3. (canceled)

4. (currently amended) A computer implement<u>ed</u> method for combining two or more risk models for providing an investor with a risk model with wider scope than its constituent parts, comprising the steps of said computer:

letting C_1 denote a class of algorithms for constructing estimates of ~~a~~ covariance matrices from time histories of data;

letting C_2 denote a class of asset classes;

for x in C_2 <u>letting</u> $C_3(x)$~~, denoting~~ <u>denote</u> a class of multi-factor risk models for x;

for y in $C_3(x)$ denoting its parts as follows:

factor exposures $X(y,t)$;

factor returns f(y,t); and

specific covariance matrix D(y,t);

giving the following components:

two or more asset classes $x_1,\ldots,x_n$,let x denote an asset class which is a union of these given asset classes;

for each asset class x_i giving a risk model y_i in $C_3(x_i)$;

letting Y(t) be such that the decomposition:

$$\begin{pmatrix} f(y_1 t) \\ f(y_2 t) \\ \\ f(y_N t) \end{pmatrix} = \begin{pmatrix} y_1(t) \\ y_2(t) \\ \\ y_N(t) \end{pmatrix} g(t) + \begin{pmatrix} \sum_1(t) \\ \sum_2(t) \\ \\ \sum_N(t) \end{pmatrix}$$

~~f(t) y(t) Σ(t)~~

$$\begin{pmatrix} f(y_1,t) \\ f(y_2,t) \\ \vdots \\ f(y_N,t) \end{pmatrix} = \begin{pmatrix} Y_1(t) \\ Y_2(t) \\ \vdots \\ Y_N(t) \end{pmatrix} g(t) + \begin{pmatrix} \phi_1(t) \\ \phi_2(t) \\ \vdots \\ \phi_N(t) \end{pmatrix}$$

$$\underline{f(t)} \;=\; \underline{Y(t)g(t)} \;+\; \underline{\phi(t)}$$

which results in residuals ~~Σ(t)~~ $\phi(t)$, such that correlations ~~(Σi (t), Σj (t)) = 0~~ (ϕ_i, ϕ_j) is nearly zero if $i \neq j$; and

constructing a risk model for x as follows:

forming $X(t) = \text{diag}(X(y_1, t),\ldots, X(y_n, t))$;

forming $D(t) = \text{diag}(D(y_1, t),\ldots,D(y_n, t))$;

applying a method C_1 to estimate a covariance matrix G(t) from a history of g(t)s; and

applying an optionally different method on C_1 to estimate a covariance matrix $\Phi(t)$ ~~$\phi(t)$~~ from a history of the ~~$\Sigma(t)$s~~ $\phi(t)s$;

wherein $X(t)[Y(t)G(t)Y(t)^t+\Phi(t)]X(t)^t+D(t)$ ~~$X(t)[Y(t)G(t)Y(t)^t+\phi(t)]X(t)^t+D(t)$~~ is a risk model for x.

5. (currently amended) A system for combining two or more risk models for providing an investor with a risk model with wider scope than its constituent parts, comprising:

computer means for denoting a class of algorithms for constructing estimates of a covariance matrices from time histories of data;

computer means for denoting a class of asset classes;

computer means for denoting a class of multi-factor risk models for said denoted class of asset classes; and

computer means for constructing risk models for each asset class as follows:

applying a method from said denoted class of algorithms to estimate a first covariance matrix from a history;

applying a ~~different~~ method from said denoted class of algorithms to estimate a second covariance matrix from a history; and

combining asset class risk models based on said class of multi-factor risk models and using said estimated first and second covariance matrices to form and output a risk model with broad coverage that is consistent with each asset class model.

6. (canceled)

7. (currently amended) A computer program product comprising a computer useable medium having control logic stored therein for causing a computer to combine two or more risk models for providing an investor with a risk model with wider scope than its constituent parts, comprising:

computer readable program code means for causing the computer to denote a class of algorithms for constructing estimates of a covariance matrices from time histories of data;

computer readable program code means for causing the computer to denote a class of asset classes;

computer readable program code means for causing the computer to denote a class of multi-factor risk models for said denoted class of asset classes; and

computer readable program code means for causing the computer to construct risk models for each asset class as follows:

applying a method from said denoted class of algorithms to estimate a first covariance matrix from a history;

applying a ~~different~~ method from said denoted class of algorithms to estimate a second covariance matrix from a history; and

combining asset class risk models based on said class of multi-factor risk models and using said estimated first and second covariance matrices to form and output a risk model with broad coverage that is consistent with each asset class model.

8. (canceled)

9. (new) The computer implemented method of Claim 4, insuring said risk model is consistent with the risk model for each asset class, further comprising the steps of said computer:

letting $F_1(t)$ be a block diagonal matrix obtained from $Y(t)G(t)Y(t)' + \Phi(t)$ by setting all elements to zero except those of the diagonal blocks corresponding to each asset class, where each such block represents the covariance among the factors explaining risk for a particular asset class;

letting $F_2(t)$ be a block diagonal matrix whose diagonal blocks contain the asset class factor covariance matrices, $F(y_i,t)$ in the same order as they appear in $F_1(t)$;

letting the off-block diagonal elements be zero;

given a real symmetric positive semi-definite matrix M, letting $M^{1/2}$ denote a square root of M such that $M^{1/2}(M^{1/2})' = M$, wherein there may be several choices for $M^{1/2}$;

letting $M^{-1/2}$ denote the inverse of $M^{1/2}$ if the inverse exists and in the event the inverse does not exist, letting $M^{-1/2}$ be a pseudoinverse; and

then forming and outputting $X(t)\{ F_2^{1/2}F_1^{-1/2}(Y(t)G(t)Y(t)' + \Phi(t)(F_2^{1/2}F_1^{-1/2})' \}X(t)'$ as a risk model that is consistent with the component asset class models.